Journal of the Andaman Science Association Vol. 23(1):1-7 (2018)
ISSN 0970-4183, Printed in India

Climate of Andaman and Nicobar Islands: Long-term pattern analysis

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Abstract

In recent decades climate change and variability have become major concern for humankind because certain human activities have been identified as significant causes of recent climate change. The present study highlights the changes in rainfall pattern and temperature over these islands from the historical and observational data. Changes in rainy days, post and pre monsoon rainfall are prominently noticed in recent times. Increase in heavy to very heavy rainfall categories (6.5 to 8.8%) was observed as compared to the climatic normal (6.5%). The challenges posed by climate change will have greater impact on Andaman and Nicobar islands by way of erratic rainfall, persistent droughts and high temperature which results in severe water crisis particularly moisture deficit during summer months. This calls for cautious but adaptation centric approach in weather and natural resource management of our Islands. Therefore, agriculture should move towards more water efficient and climate resilient crops.

Keywords: *rainfall, frequency distribution, temperature, long-term average, weather, Bay Island*

Introduction

Since the beginning of the 20th century there have been notable changes in surface temperature, rainfall, evaporation and extreme events as a result of human activities. In this context, climate change has been receiving more attention of scientists, policy makers and common men with different perceptions. The term climate change means "any significant change in the statistical distribution of weather patterns over periods ranging from decades to millions of years". It may be a change in average weather conditions or the distribution of events around that average. Climate change may be limited to a specific region or may occur across the whole Earth. If the weather parameters show year-to-year variations or cyclic trend, it is known as climate variability (IPCC, 2001). The reality of climate change is evident and the likely effects are broadly predicted, although still uncertain with regard to the nature, rate and extent to which such changes will occur. The impact is dominantly felt on agricultural production which will have significant effects on small holder farmers in many parts of the tropics and subtropics, and the resulting reduced food security potentially will increase the risk of hunger and under nutrition (HLPE, 2012).

Globally, there are many studies related to precipitation trend and pattern. Analyses of global precipitation pattern show variations and some notable trends in recent decades. Few studies have shown a rising trend in precipitation over the middle and high latitudes of northern hemisphere. There are also many studies related to precipitation trend and pattern over India (Guhathakurta and Rajeevan 2006; Rajeevan et al., 2008). But, there are only few studies related to rainfall pattern and its variability over Andaman and Nicobar Islands. In addition, the understanding of weather variations and impact of global changes on these islands are very essential due to its geography, unique biodiversity and coexistence of mainstream population with tribals. In view of this, an attempt has been made to study the changes and variations in climatic parameters at various time intervals and its possible impact on the island ecosystem.

Materials and Methods

Assessment of climatic parameters requires reliable data recorded over long period of time. In the present study climatic data pertaining to different stations across the Island were collected from India Meteorological Department, Andaman and Nicobar Administration and Central Island Agricultural Research Institute. The data was verified for consistency and continuity before creating climatic data base. From this data base the changes and trend in annual and seasonal rainfall and rainy days were extracted. Probability analysis was carried out by using RAINSIM to estimate the length of dry spell using historical climatic data pertaining to these Islands. Remote sensing data (IRS P6) was used to derive the land use / land cover of these islands which are verified by field survey and in house information available with Central Island Agricultural Research Institute. A rainy day over a station is considered when it reported more than 2.5 mm rainfall in a day. Sea surface temperature (SST) maps from the NASA JPL–PODAAC site available in HDF format were read using the software binary codes provided with the data and converted to tiff image format. Further processing was done using ERDAS–IMAGINE and ARC–GIS software for display and analysis of the maps. .

Agro-climate of Andaman and Nicobar Islands

The Andaman and Nicobar group of Islands lie in the Bay of Bengal (6-14^0 N lat; 92-94^0 E long) 1200 km east of mainland India. The climate of Andaman and Nicobar Island is typified by tropical conditions with little difference between mean summer and mean winter temperatures. The annual rainfall varies from 2900 to 3100 mm representing perhumid climate. As these islands are situated close to the equator intensive solar radiation is received resulting in high evaporation especially during dry months which far exceeds the rainfall resulting in water deficit condition. The rainfall covers the potential evapotranspiration demands, except for seasonal water deficit of 300-400 mm during the post-monsoon period (January to April). The average relative humidity varies from 68 to 86% and the maximum and minimum temperature is 32°C and 22°C, respectively. The length of growing period is more than 210 days which is long enough to support double cropping and plantation crops grown in the area. The area experiences **Udic** soil moisture and **Isohyperthermic** soil temperature regime. As these islands are topographically undulating, characterized by hills and narrow longitudinal valley there is limited scope for surface water storage.

Results and Discussion

The long-term trend

The long term trend in climatic parameters indicated that these Islands experience hot and humid tropical climate with least variation in maximum and minimum temperatures in major part of the year (Fig. 1). The mean relative humidity in these Islands is 79%, the mean maximum temperature is 30.2° C, and mean minimum temperature is 23.0° C. On an average there has been no significant change in the long-term temperature pattern.

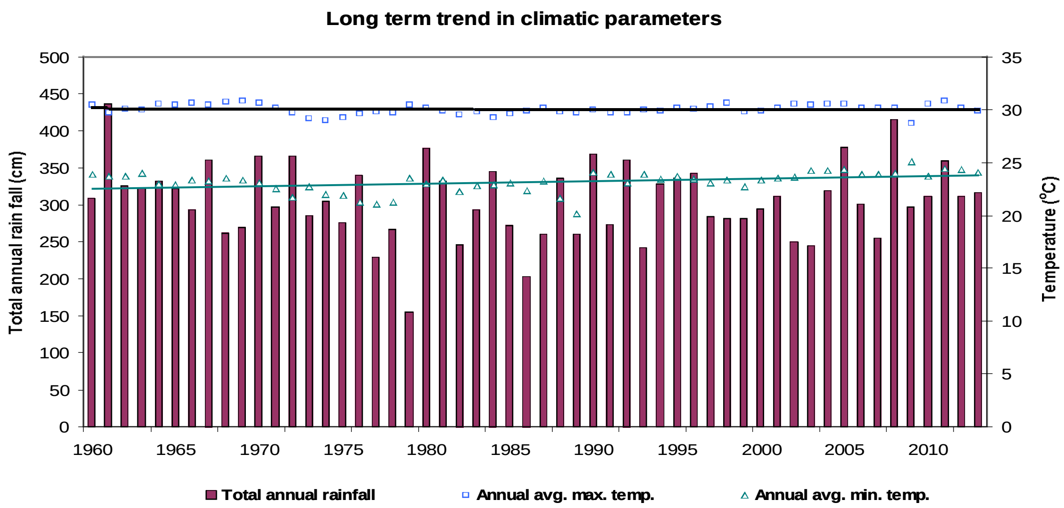


Fig. 1 Long-term trend in climatic parameters over Andaman and Nicobar Islands

These Islands receive annual average rainfall of about 3100 mm with the highest rainfall experienced in 1961 (4362 mm) and the lowest in 1979 (1550 mm). Among the two Island groups, Andaman receives more annual rainfall than Nicobar Islands though it is located in the equatorial belt. About 95 percent of annual rainfall is received during May-December but a deficit of about 610 mm is experienced during January-April when number of rainy days in each month hardly exceeds three. The annual rainfall over Port Blair is the highest (3100 mm) whereas Nancowry receives the lowest annual rainfall (2480 mm).

In season wise distribution, average rainfall is maximum in monsoon and minimum in winter (Fig. 2). On an average this Islands has 136 days of rainy days. The average monsoon seasonal rainfall over Andaman Islands is 173 cm with 73 rainy days, whereas it is 113 cm with 56 rainy days over Nicobar Islands. In contrast during winter season, the average total rainfall over Andaman Islands is only 6 cm with 3 rainy days but it is higher at 17 cm with 9 rainy days over Nicobar Islands.

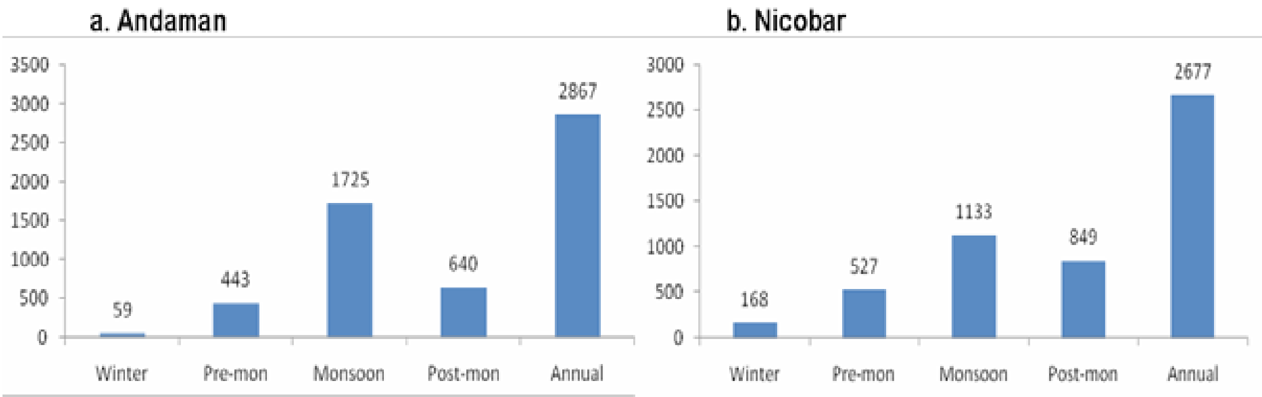


Fig. 2 Annual and seasonal rainfall (mm) in Andaman and Nicobar Islands

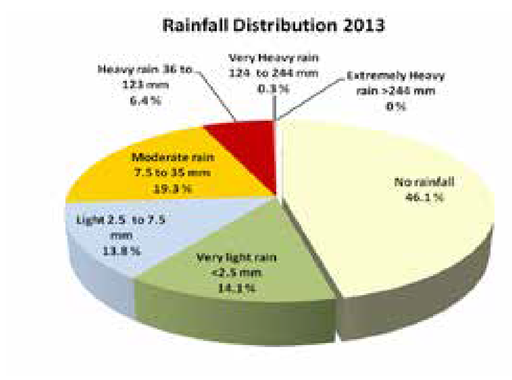
Another important aspect of island rainfall pattern is weekly performance. Historical weekly rainfall for Port Blair was analyzed using RAINSIM software and the weekly probable rainfall was estimated. The results indicated that at normal probability distribution function fitted at 1% level of significance for all except for 24, 36 and 45 standard meteorological weeks. In Andaman and Nicobar Island atleast 60% of the normal rainfall is received with maximum probability however the probability of getting 80% of normal rainfall is between 60-80% chances. Most important feature of the analysis was that the probability of getting rainfall decreases in post monsoon period during which the Island faces moisture stress condition. Though the average rainfall and rainy days are low during dry period, some amount of rainfall is received atleast in 1-2 rainy days. This is very vital for the entire vegetation in Andaman and Nicobar Islands and also provides scope for rainwater harvesting in summer months. Therefore, creation of water harvesting and storage structures for providing supplemental irrigation to crops is very essential for successful agriculture.

Changes in climatic parameters

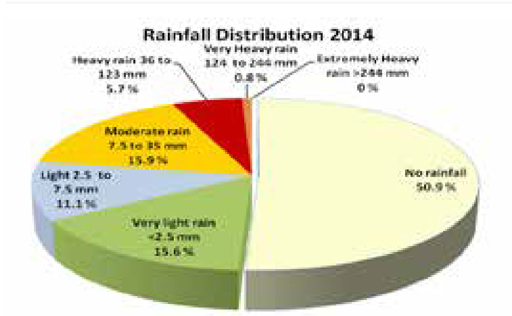
The climate regimes of small islands located in the Indian Ocean are predominantly influenced by the Asian monsoon; the seasonal alternation of atmospheric flow patterns which results in two distinct climatic regimes: the south-west or summer monsoon and the north-east or winter monsoon, with a clear association with ENSO events (Mimura et al., 2007). In response to the global level changes, in recent years, the rainfall pattern and its frequencies of Andaman and Nicobar islands have shown trend which are deviation from the climatic normal. Most of these changes were observed in its seasonal distribution pattern rather than annual mean values which results in extreme events perhaps with large uncertainty.

Analysis of rainfall frequencies of Andaman and Nicobar islands (2013-16) indicated increase in heavy to very heavy rainfall categories which ranged from 6.5 to 8.8% as compared to the climatic normal (6.5%). On the other hand the percentage of total rainless days and total rainfall remains more or less unchanged (Fig. 3). This means that the total number of rainy days remains same but the category of rainfall event has changed. Yet this doesn't explicitly indicate anything on the occurrence of drought or moisture stress whereas flooding is experienced in different months due to increase in heavy rainfall events. The recent experiences of flooding from 2013 to 2016 showed that heavy rainfall is not the phenomena of monsoon season, it also happened even during the post monsoon and premonsoon season as well. Thus the analysis suggested that uncertainty associated with flooding has come down. In other words the predictability of flooding due to heavy rainfall has increased. The major rainfall frequency category is light to moderate rainfall which is the characteristic feature of island climate.

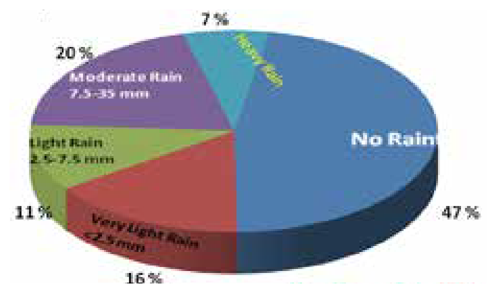
2013



2014



2015



2016

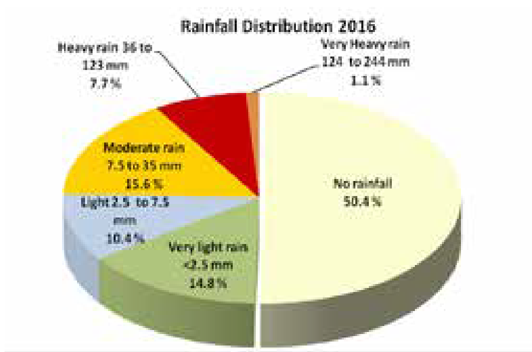


Fig. 3. Frequency distribution of rainfall during 2013-16

Monsoon performance

The performance of monsoon is vital for agricultural growth and food security of our country. Of late, it started reflecting on our overall economy as well. In Andaman and Nicobar Islands the performance of rainfall during monsoon and summer season is equally important, as the entire island is rainfed. The islands receive rainfall from both southwest and northeast monsoon. Since the islands are mostly discrete and the topography, types of vegetation, forestry as also the geographical localizations are varied the rainfall distribution is highly varied and anomalous. These can be quite evident from the rainfall record of the islands. The long period average (LPA) of the annual rainfall of the islands for the period 1949-2005 is 3070 mm which is received in 143 rainy days (Fig. 4). The South-West monsoon (June - September) accounted for 60.8 % of total annual rainfall followed by 22% in North-East monsoon period (October-December). Only 4.8% of the total rainfall is received during summer (January- April) and the rest 12.3% is received during post monsoon season (May). Out of twelve months in a year these islands experience wet condition for 8 months and the remaining 4 month dry condition. During the active monsoon periods, occasionally, a few low-pressure waves originating in the ITCZ move westwards across the southern peninsula without touching Andaman Sea or Western Bay of Bengal. When this happens there is a sudden decrease of rainfall over this island along with intensive solar radiation which favours high evapotranspiration. This creates a break in monsoon consequently stress in the plant system particularly kharif rice due to high evapotranspiration and soil moisture deficit.

During 2016 the Islands received a total annual rainfall of 3542.8 mm which was 97% of the total annual rainfall while only 3% of total rainfall was received during summer season. As compared to 2015 performance it was 14% excess rainfall. While the average of 2011-15 showed that 88% of total annual rainfall was received in monsoon season while 12% was received during summer season. As it is not the cyclic events, therefore, in a decadal scale, this indicated the deviation of monsoon pattern rather than trend. However, the data suggested that the extreme events in the island have increased during this period.

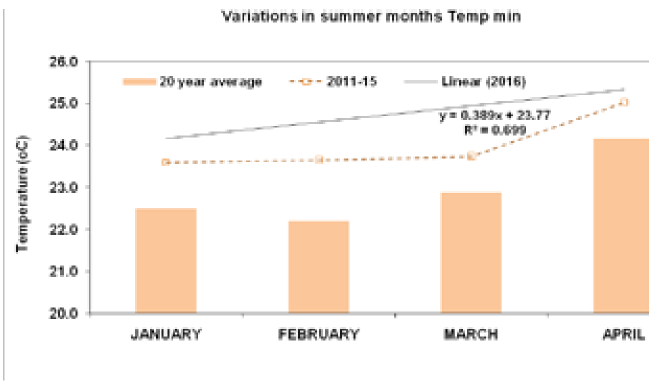


Fig. 4. Variation in monthly rainfall during the monsoon period

The data presented above supports the view that the southwest monsoon is well marked over these islands but the activity of the southwest monsoon is not uniform in time and space during the whole season.

4.3 Temperature pattern

Maximum temperature

The tropical island of Andaman and Nicobar experience hot and humid climate which is strongly influenced by the conditions of the surrounding sea. Further, the sea surface temperature also influences the coastal temperature besides direct effect on the coral reef and the reef biodiversity. Normally summer months maximum temperature ranges fro 28 to 32 °C and beginning from January it starts increasing. It moves up and down around the normal mean but with in -1 °C to +1 °C. However, in recent times the maximum temperature is always above the normal temperature by more than 1 °C. This is in conformity to the IPCC projection of general warming trend in surface air temperature in all small-island regions and seasons (Lal et al., 2002). During January to April, 2011 to 2015 the maximum air temperature was higher compared to the average maximum temperature. Similar trend was observed for 2016 as well. For January and February it was above normal (+2 °C) and during March-April it was appreciably above normal (+3.5 °C). Continuing with the new trend in January 2016 it was markedly above normal (+6.4 °C) temperature. This may be linked with the global warming phenomena or long term cyclical changes. But the aberration has profound effect on the island agriculture and water resources.

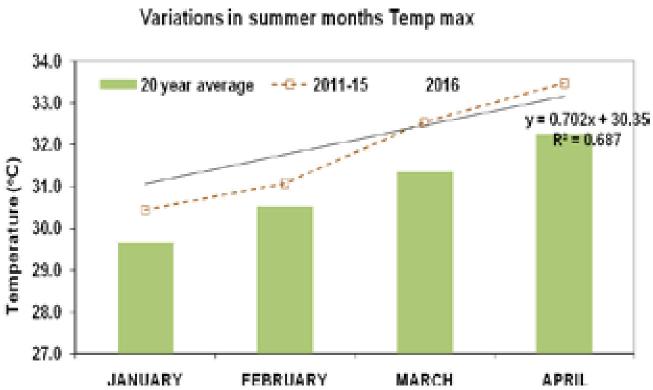


Fig. 9. Variation in summer months maximum temperature

Minimum temperature

The increase in minimum air temperature is very important aspect of global climate change than the maximum temperature. This affects several life processes besides adaptation and survival of plants and animals. The analysis of minimum temperature from 2011 to 2015 showed that during January - February, the increase was markedly above normal while during March - April it was appreciably above normal. In 2016 rapid increase in minimum temperature was observed and it touched severe heat wave condition.

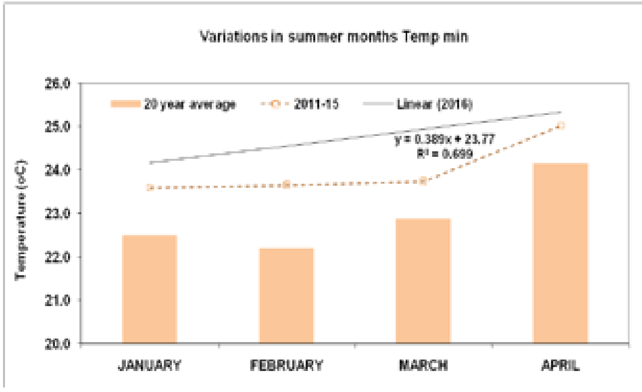


Fig. 10. Variation in summer months minimum temperature

The analysis showed that the percentage of days having very warm maximum or minimum temperatures has increased considerably since the 2011 while the percentage of days with cold temperatures has decreased when compared to the long-term average. In this context it is worth mentioning the projected increase in surface air temperature for all regions of the small islands for the three 30-year periods (2010 to 2039, 2040 to 2069 and 2070 to 2099) relative to the baseline period 1961 to 1990 using coupled atmosphere ocean general circulation models (Ruosteenoja et al., 2003).

Impact on agriculture

Although the interactions of global climate change and crop nutrition are not well understood, it is probable that the net effects of these changes will be negative for agricultural production. This is more pertinent to the island ecosystem of Andaman and Nicobar which is vulnerable to climate change events. Agricultural productivity is sensitive to two broad classes of climate induced effects, one is the direct effects due to changes in temperature, precipitation and carbon dioxide concentrations and the other is the indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases (Mendelsohn, 2014). Drought induced by higher temperatures and altered rainfall distribution would reduce nutrient acquisition, biological nitrogen fixation, and may disrupt nutrient cycling. This may render agriculture unproductive or results in crop failure particularly during post monsoon seasons. On the other hand, more intense precipitation events during monsoon season would reduce crop nutrition by causing short-term root hypoxia, and in the long term by accelerating soil erosion. Increased temperature will reduce soil fertility by increasing soil organic matter decomposition, and may have profound effects on crop nutrition by altering plant phenology (St.Clair and Lynch, 2010). The main effect of climate change on agriculture are, productivity including livestock, in terms of quality and quantity, changes in water use and agricultural inputs, and environmental effects. In general, the negative impacts of climate change on agriculture will far exceed beneficial effects, which would intensify food insecurity.

Adaptation to changes

Averting the challenge posed by changing weather pattern requires that farmers adapt by making changes in farming and land management decisions that reduce the negative consequences associated with changing climate (Jarvis et al., 2011). The adaptation options may include increasing the resilience of existing farming systems, diversification and risk management (Thornton and Herrero 2014). *In situ* water harvesting technologies would help to address the water shortage issue due to changes in rainfall pattern and cope with the El Nino effect. From the viewpoint of immediate adaptation to dry conditions all possible methods have to be used to harvest and store the rainwater as and when it occurs. It can be accomplished by (a) Lined tank for hill top (b) rooftop rainwater harvesting (c) Broad bed furrow system for lowlying areas (d) Check dam for mid hill areas and (b) Ring well downstream of check dam (Velmurugan et al., 2011). The seepage loss from earthen tank is quite high in the hilly areas due to coarse soil texture and porous coral base at lower stratum. Lining of ponds with silpaulin followed by covering with tiles is suitable. In Nicobar group of Islands during dry season water is scare and ground water become saline as a consequence rainwater harvesting is very essential. On an average the roof area of a group house (tuhet) is 300 m^2 and the rainwater falling on the roof is 9,00,000 liters. If we assume 70% collection efficiency then 6,30,000 liters of rainwater is available for collection. This can be effectively used to provide irrigation to crops grown in the homestead garden during dry season and as drinking water for livestock.

Conclusions

The challenges posed by climate change will have greater impact on these islands by way of erratic rainfall, persistent droughts, and high temperature besides changing policy environment within which they operate. This calls for cautious but adaptation centric approach in weather and natural resource management of our Islands. Therefore, agriculture should move towards more water efficient and climate resilient crops. Enhanced efforts are essential for localized harvest and storage of rainwater, recharge of ground water resources in addition to its efficient use for profitable farming system to gear up ourselves for any climate change effects in the future.

References

Guhathakurta, P. & Rajeevan, M. (2006). Trends in rainfall pattern over India, *Int. J. climatol.*, **28,** 1453-1469.

HLPE, (2012). HLPE (High Level Panel of Experts), 2012. Food Security and Climate Change. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2012.

IPCC (2001). Intergovernmental Panel on Climate Change. *Climate Change 2001: Third Assessment Report (Volume I)*. Cambridge University Press, Cambridge, UK.

Jarvis, A., Lau, C., Cook, S., Wollenberg, E., Hansen, J., Bonilla, O. & Challinor, A. (2011). An Integrated Adaptation and Mitigation Framework for Developing Agricultural Research: Synergies and Trade-offs. Experimental Agriculture 47(02): 185–203.

Mendelsohn, R. (2014). The impact of climate change on agriculture in Asia. Journal of integrative Agriculture, 13, 660-665.

Mimura, N., Nurse, L., McLean, R.F., Agard, J., Briguglio, L., Lefale, P., Payet, R. & Sem, G. (2007). Small islands. Climate Change (2007):Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK 687-716

Rajeevan, M., Bhate, J. & Jaswal, A.K. (2008). Analysis of variability and trends of extreme rainfall events over India using 104 years of gridded daily rainfall data, *Geophys. Res. Lett.*, **35**, L18707, doi:10.1029/2008GLO35143.

Ruosteenoja, K., Carter, T.R., Jylha, K. & Tuomenvirta, H. (2003). Future climate in world regions: an intercomparison of model-based projections for the new IPCC emissions scenarios. The Finnish Environment 644, Finnish Environment Institute, Helsinki p.83.

St.Clair, S.B. & Lynch, J.P. (2010). The opening of Pandora's Box: climate change impacts on soil fertility and crop nutrition in developing countries, Plant Soil, 335:101–115

Thornton,P.K. & Herrero, M. (2014). Climate change adaptation in mixed crop-livestock systems in developing countries. Global Food Security, 3(2): 99-107.

Velmurugan, A., Kundu, A.S., & Ambast, S.K. (2011). *Water resource management for sustainable agriculture and livelihood improvement*, CARI, Port Blair, India. p.182.